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USNC-IGY ANTARCTIC GLACIOLOGICAL DATA
FIELD WORK 1958 AND 1959

(The Petrography of Some Rocks From
Marie Byrd Land, Antarctica)

Report 825-2-Part VIII
IGY Project No. 4.10

NSF Grant No. Y/4.10/285

V. H. Anderson
September 1960

USNC-IGY ANTARCTIC GLACIOLOGICAL DATA

Report Number 2: Field Work 1958-59

Part VIII

THE PETROGRAPHY OF SOME ROCKS FROM MARIE BYRD LAND, ANTARCTICA

by

V. H. ANDERSON

The Ohio State University
Research Foundation
Columbus 12, Ohio

Project 825, Report No. 2, Part VIII

Submitted to the

U. S. National Committee for the IGY
National Academy of Sciences, in partial fulfillment
of IGY Project Number 4.10 - NSF Grant No. Y/4.10/285

September 1960

ABSTRACT

Rock specimens from newly-discovered mountain masses and nunataks in Marie Byrd Land, Antarctica, are described. Four chemical analyses of volcanic rocks from Mt. Takahe are presented. The volcanic specimens, identified as oligoclase andesite, reflect a marginal-continental occurrence, typical of the Circum-Pacific volcanoes.

Petrographic, lithologic, and structural evidence suggest that the Sentinel Mountains structure can be extended for about 200 miles southwestward to Mt. Johns and Mt. Ewing. Detailed petrographic descriptions of 80 thin sections are presented.

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The Petrography of Some Rocks from
Marie Byrd Land, Antarctica

by

V. H. Anderson

INTRODUCTION

The Byrd Station Traverse party of 1957-1958 collected rock specimens from several mountains and nunataks while conducting glaciological investigations in the interior of Marie Byrd Land, Antarctica (Fig. 1). Considered in this report are the occurrence, petrography, and geological significance of the specimens collected from Mt. Takahe, Mt. Johns, Mt. Ewing, and some nunataks located a few miles west of the Sentinel Range. The microscopic petrographic descriptions are given in Appendix I and II. A summary of the major features of these mountains is given in Table I.

An expression of gratitude is directed to Dr. R. P. Goldthwait, Professor of Geology at The Ohio State University and Director of the IGY Glaciological Data Reduction Center at The Ohio State University Research Foundation. Valuable suggestions, criticism, and guidance were given by Dr. R. S. Houston and Dr. R. B. Parker, members of the faculty of the Department of Geology, University of Wyoming. Sincere thanks are also extended to Dr. S. H. Knight, Chairman of the Department of Geology, University of Wyoming, for authorizing the use of the facilities of the Geology Department.

MT. TAKAHE

Mt. Takahe, 76°16.4' S., 112°14' W., rises to an elevation of 3,480 meters, 2,170 meters above the surface of the surrounding ice sheet (Figs. 1 and 2). It is a low, broad shield volcano, probably of fairly recent origin, and is almost completely covered by glacier ice and snow.

At the top of Mt. Takahe is a snow-covered caldera, 70 meters in diameter; a volcanic neck 10 meters in diameter and 15 meters high occurs in the central part (Figs. 3 and 4). Specimens were collected from a parasitic cinder cone (Fig. 5) and a volcanic neck at the base of the southwest flank of Mt. Takahe. The cinder cone is broad, about 100 meters in diameter, and subdued. Most of the samples from the cinder cone were collected from scree and rubble piles, as only one or two partially consolidated ridges of rock were exposed.

In both areas, plutonic rocks (Fig. 6), presumably incorporated fragments, were observed and collected.

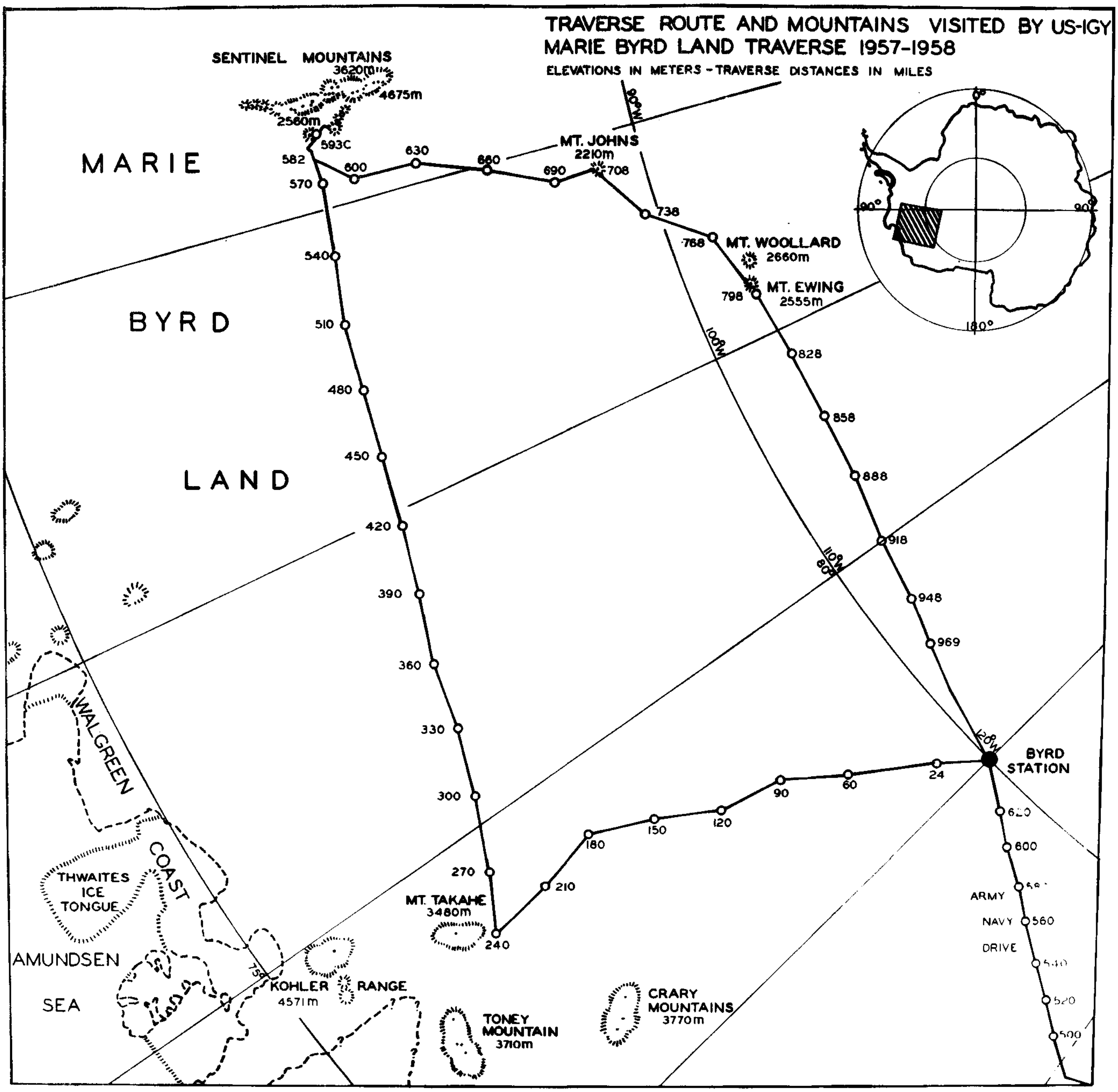


Fig. 1. Index map.

MOUNTAINS	POSITION Latitude Longitude	APPARENT STRUCTURE	LITHOLOGY	LIGHT MINERALS	HEAVY MINERALS	REMARKS
Mt. Takahe	$76^{o}16.4'$ S $112^{o}14'$ W	shield-type volcano	oligoclase andesite	- - -	- - -	samples from volcanic neck and parasitic cone
Sentinel Range Fisher Nunatak (SF Series)	$77^{o}36'$ to $78^{o}27'$ S $85^{o}53'$ to $87^{o}27'$ W	dipping 60^{o} East; numerous faults	green quartzite	quartz, calcite, plagioclase, microcline	chlorite, muscovite, epidote, hematite	bedding shown in some specimens
			green chlorite schist	quartz, calcite, plagioclase	garnet, epidote, hematite, chlorite, muscovite	cut by quartz and calcite veins; some hematite staining
Sentinel Range Larsen Nunatak (SL,S3,S4 Series)		(only a few outcrops)	green schistose quartzite	quartz, calcite, plagioclase	epidote, chlorite, sphene, muscovite, garnet, hematite, magnetite	veins of quartz and calcite
			black quartzitic sandstone	- - -	garnet, zircon, sphene, magnetite	slightly metamorphosed.
Mt. Johns (J Series)	$79^{o}37'$ S $91^{o}14'$ W	dips 4^{o} toward N70^{o}W (only two outcrops)	green quartzite	quartz, plagioclase, microcline, carbonates	garnet, zircon, sphene, tourmaline, corundum, chlorite, apatite, hematite	relatively free of mineralized fractures and veins; ripple marks, graded bedding are present
Mt. Ewing (E Series)	$80^{o}25.2'$ S $97^{o}45'$ W	dips 50^{o}-80^{o} toward S40^{o} - 50^{o}E	tan to brown quartzitic sandstone and quartzite; green chlorite schist	quartz, plagioclase	muscovite, chlorite, limonite	calcite and quartz veins, stringers and mineralized fractures; quartzitic sandstone slightly metamorphosed

Table 1. Summary of major features of some mountains in Marie Byrd Land, West Antarctica.

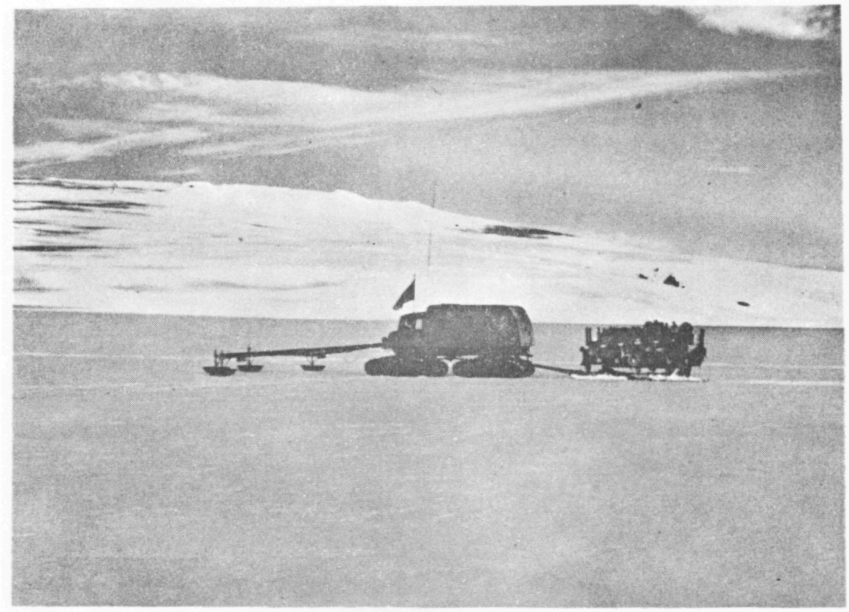


Fig. 2. Traverse vehicle approaching Mt. Takahe.

Fig. 3. Volcanic neck and small caldera on Mt. Takahe; Crary Mountains in background.

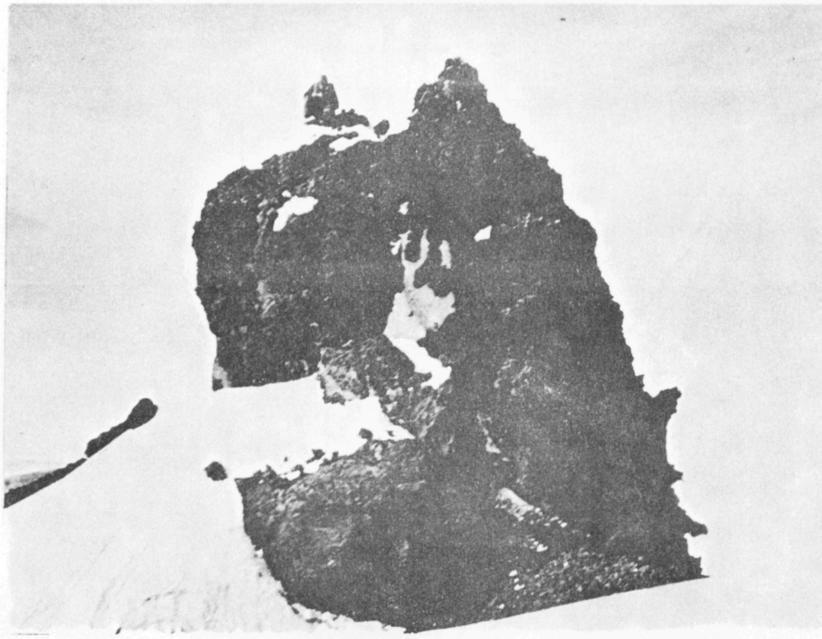


Fig. 4. Close-up of volcanic neck on Mt. Takahe.

Fig. 5. Parasitic cinder cone on Mt. Takahe.

Megascopic Description

The rocks from the cinder cone are dark gray, vesicular andesites. Most are scoriaceous and consist of spherical vesicles which range from less than one to five millimeters in diameter. Some specimens consist entirely of massive glass (Fig. 7). Many specimens are porphyritic and exhibit skeletal phenocrysts of plagioclase.

The volcanic neck is roughly cylindrical and exhibits flow lines which are parallel to the long axis of the neck. The rock is fragmental and consists of a fine-grained, brownish matrix which contains fragments of volcanic and plutonic rocks. The plutonic rock fragments are similar to those which occur in the float on the cinder cone. Small fragments are aligned, whereas the larger fragments are randomly oriented. Earlier magmatic phases, represented by fragments of volcanic rock, are partially resorbed by later phases of the magma.

Microscopic Description

The microscopic descriptions of petrographic thin sections cut from Mt. Takahe specimens are given in Appendix I.

The ground mass of the vesicular andesite of Mt. Takahe consists of randomly oriented, plagioclase microlites and opaque, brownish glass (Fig. 8).

The phenocrysts consist of skeletal plagioclase crystals, olivine, and augite (Fig. 9). The plagioclase is andesitic oligoclase. It is usually zoned, subhedral, and not twinned. Euhedral phenocrysts of unaltered oligoclase show Carlsbad and albite twins.

Pyroxene phenocrysts are commonly euhedral crystals of diopsidic augite (Figs. 10 and 11) and show the characteristic pyroxene cleavage. Olivine occurs as large, euhedral crystals and as small, anhedral crystals disseminated throughout the groundmass (Fig. 12). Magnetite is abundant and is closely associated with olivine. Many small (< 0.01 mm) olivine crystals contain inclusions of euhedral magnetite. Clusters of magnetite crystals and individual crystals are also scattered throughout the groundmass. Apatite is generally present.

The groundmass of specimens of the volcanic neck consists of brownish, almost opaque, glass. Slightly deformed shards are aligned parallel to flow structure. Phenocrysts are scarce (Fig. 13).

Chemical Character of Four Volcanic Rocks

Four samples of the volcanic rocks from Mt. Takahe were analyzed by Mr. C. Trimble of the Natural Resources Institute of the University of Wyoming (Tables 2, 3, 4, 5, and 6). In addition to the analysis, the norm and C.I.P.W. classification are given. For comparison, chemical analyses and norms of other specimens from Antarctica and elsewhere are presented in Table 7.

The volcanic rocks from Mt. Takahe are richer in alkalies and poorer in magnesium than either common basalt or andesite. The ratios of CaO to Na_2O and K_2O to MgO are significantly different from those of the oceanic, olivine basalts and the tholeiitic flood basalts (Table 8).

Andesites characterized by a high percentage of alkalies and an intermediate silica content (about 50 per cent) are frequently referred to as andesine basalts or oligoclase andesites. The lavas of Deception Island at the southern end of the South Shetland Island Arc belong to this category (Tyrrell, 1945).

The mineralogy and chemical composition of the volcanic rocks from Mt. Takahe indicate that they are oligoclase andesites and are very similar to the Hawaiian oligoclase andesites (Table 9).

The oligoclase andesites of Mt. Takahe probably are representative of a petrographic province confined to continental sectors of the earth's crust. According to Turner and Verhoogen (1951, p. 212):

> "Eruption of andesitic lavas and tuffs, with which olivine basalts are usually associated at some stage of the igneous cycle, is a highly characteristic accompaniment of orogeny, especially in its later stages. This volcanic association is not limited to areas of strong folding. But it is confined to continental sectors of the earth's surface, and its most typical development is in connection with moderate to strong orogenic movements such as continually affected the Pacific margins through the latter part of geologic time."

Since Mt. Takahe is located near the continental border of West Antarctica, it is suggested that this area represents a segment of the Circum-Pacific volcanic belt. Seismic data (Ostenso and Bentley, 1959) indicate that an open sea would exist between Mt. Takahe and the rest of the continent if it were ice-free and that isostatic readjustment of the earth's crust in this area would not bring any sizeable portion of the crust above sea level.

Similar Rock Types in the Area West of Mt. Takahe

Similar volcanic rocks may exist in two mountain masses west of Mt. Takahe. They were located during the traverse (Fig. 1) and were named the Crary Mountains and Toney Mountain (Fig. 14). These mountains were not visited. However, it is reported that the Executive Committee Range (77°20' S., 129°W.) is composed of a series of volcanic rocks (Antarctic Notes, 1959). The Crary Mountains and Toney Mountain lie between the Executive Committee Range and Mt. Takahe; consequently, they may also consist of volcanic rock.

The Kohler Range, which was sighted to the north of Mt. Takahe, has a sharp profile and is characterized by peaks (Fig. 15). Because the volcanic ranges are generally characterized by a domal profile, this suggests that the Kohler Range consists of rocks more resistant than the volcanic rocks of the other mountains.

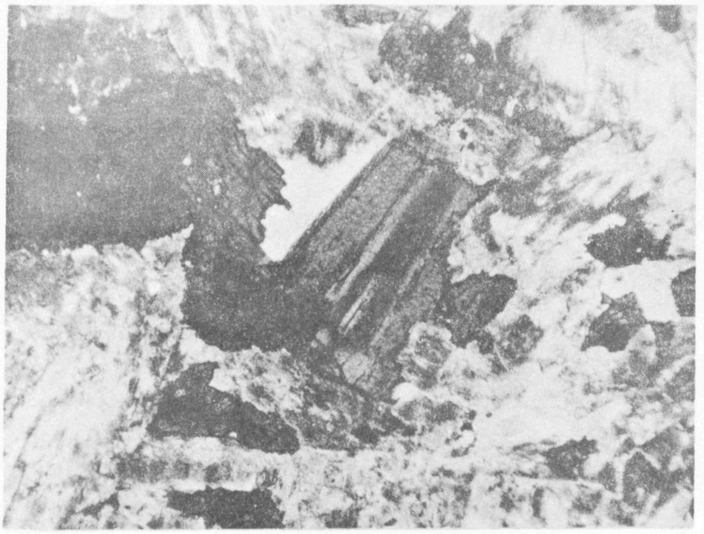
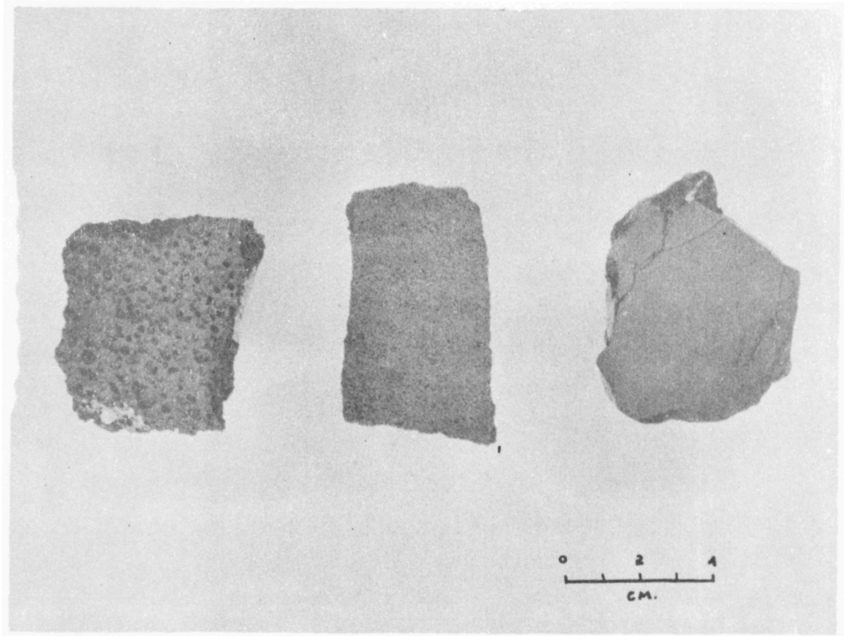


Fig. 6. Syenite, sample T-12. Consists of randomly oriented albite and aegerine-augite. Plain light X 55.

Fig. 7. Textural variations in some Mt. Takahe specimens from the cinder cone, T-1, T-5, T-11.



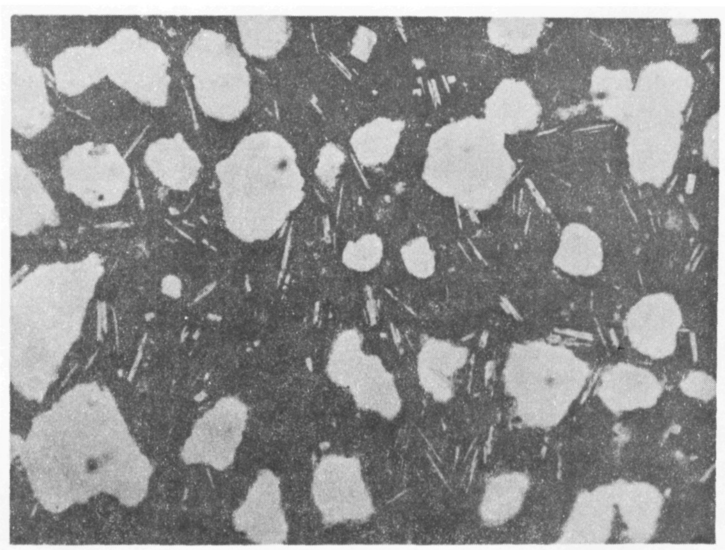


Fig. 8. Microlites of oligoclase in a matrix of magnetite-rich glass. Sample T-4, vesicular oligoclase andesite. Plain light X 55.

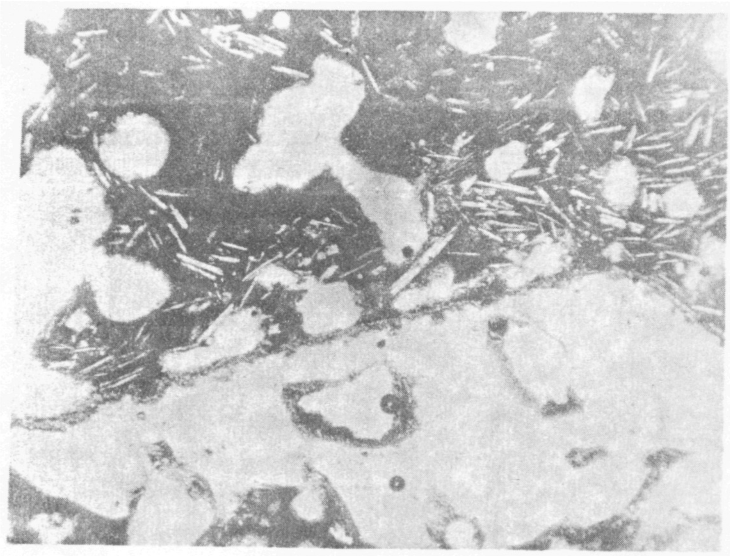


Fig. 9. Skeletal plagioclase phenocryst in a matrix of microlitic oligoclase and magnetite-rich glass. Sample T-B, vesicular oligoclase andesite.

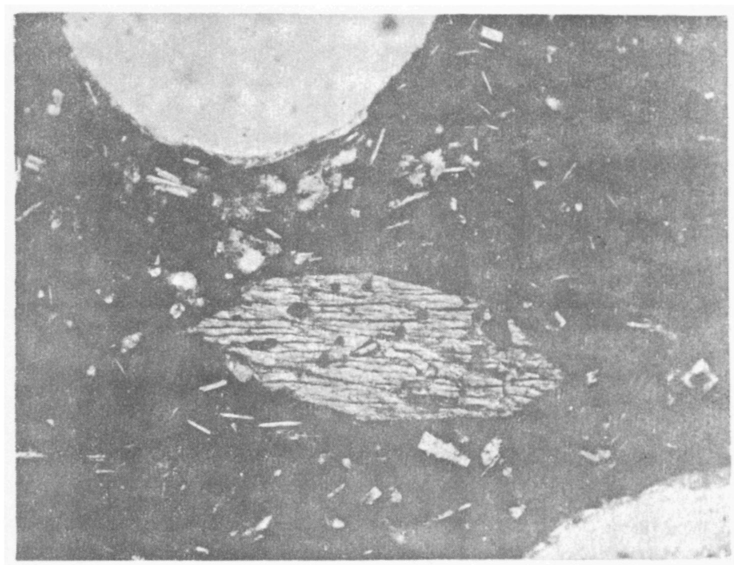


Fig. 10. Typical, oval-shaped pyroxene phenocryst in vesicular oligoclase andesite. Sample T-2. Plain light X 55.

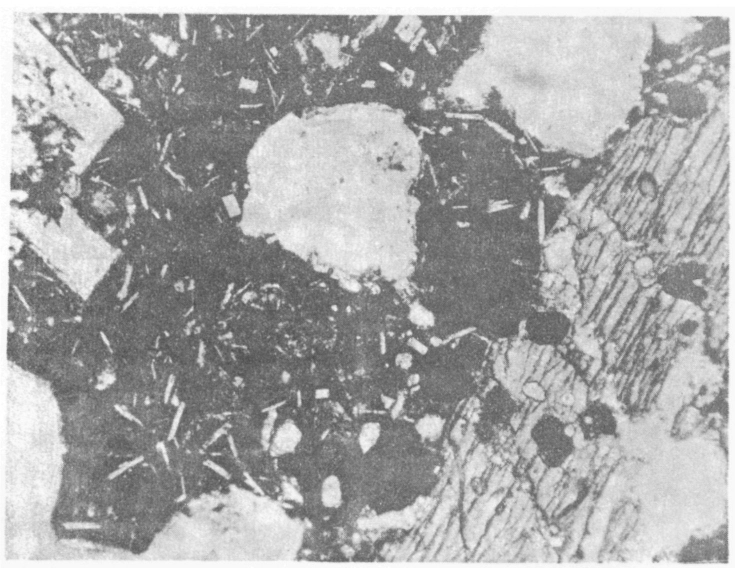


Fig. 11. Inclusions of magnetite and olivine in a pyroxene phenocryst in right side of photograph. Oligoclase phenocryst in upper left portion of photograph. Sample T-1, vesicular oligoclase andesite. Plain light X 55.

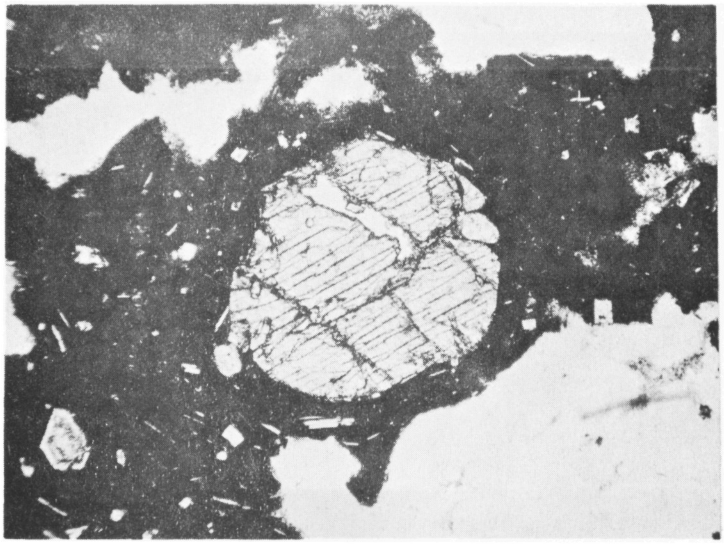


Fig. 12. Olivine phenocryst present in sample T-C, vesicular oligo clase andesite. Plain light X 55.

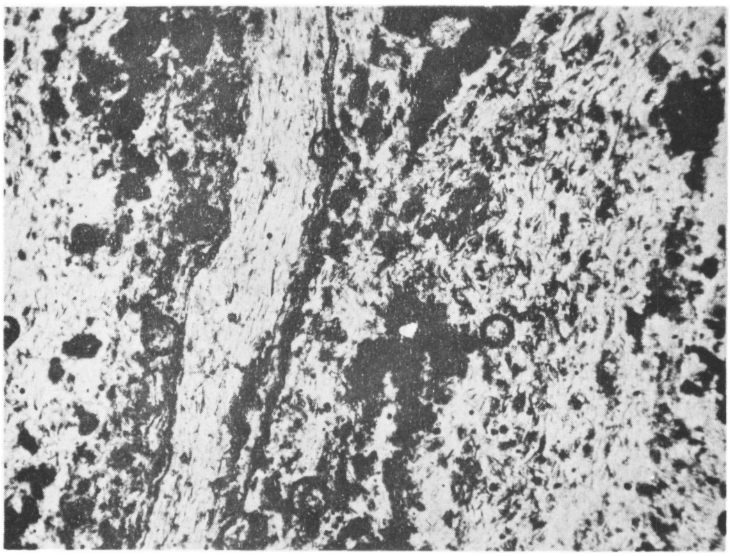


Fig. 13. Crystallites and shards present in sample T-D, a dense, blackish-brown glass. Magnetite is disseminated throughout the glass. Plain light X 55.

TABLE 2. Chemical Analysis, Norm, and C. I. P. W. Classification of Sample Takahe-A.

Chemical Analysis	Wt. %
SiO_2	50.16
TiO_2	2.63
Al_2O_3	15.87
Fe_2O_3	1.55
FeO	8.75
MnO	0.082
MgO	4.30
CaO	7.01
Na_2O	5.04
K_2O	2.39
P_2O_5	1.16
ZrO_2	0.05
Li_2O	0.052
H_2O+	0.22
H_2O-	0.11
CO_2	ND
S	0.086
Total	99.46

Norm	
Orthoclase . . .	13.90
Albite	29.34
Anorthite . . .	13.62
Nelphelite . . .	7.10
Diopside	16.76
Olivine	9.44
Magnetite . . .	2.32
Ilmenite	5.02
Apatite	1.30
Pyrite	0.17
	98.97

C. I. P. W. Classification

II(III).5(6).2'.4.

kilauose-akerose

Chemical analysis by C. Trimble

TABLE 3. Chemical Analysis, Norm, and C. I. P. W. Classification of Sample Takahe-B.

Chemical Analysis	Wt. %
SiO_2	49.94
TiO_2	3.05
Al_2O_3	15.44
Fe_2O_3	nil
FeO	10.30
MnO	0.087
MgO	4.35
CaO	8.38
Na_2O	4.48
K_2O	1.90
P_2O_5	1.36
ZrO_2	0.05
Li_2O	0.055
H_2O+	0.13
H_2O-	0.12
CO_2	ND
S	0.082
Total	99.73

Norm	
Orthoclase . . .	11.12
Albite	26.72
Anorthite . . .	16.50
Nephelite . . .	5.96
Diopside	20.42
Olivine	10.70
Magnetite . . .	-----
Ilmenite	5.78
Apatite	1.59
Pyrite	0.17
	98.96

C. I. P. W. Classification

(II)III.(4)5.(2)3.4.

camptonose-andose

Chemical analysis by C. Trimble

TABLE 4. Chemical Analysis, Norm, and C. I. P. W. Classification of Sample Takahe-C.

Chemical Analysis	Wt. %
SiO_2	50.73
TiO_2	2.80
Al_2O_3	15.86
Fe_2O_3	1.20
FeO	8.79
MnO	0.041
MgO	4.53
CaO	7.36
Na_2O	4.88
K_2O	2.19
P_2O_5	1.22
ZrO_2	0.06
Li_2O	0.047
H_2O+	0.14
H_2O-	0.08
CO_2	ND
S	0.08
Total	100.01

Norm	
Orthoclase . . .	12.79
Albite	30.92
Anorthite . . .	14.73
Nephelite . . .	5.68
Diopside	17.19
Olivine	9.62
Magnetite . . .	1.86
Ilmenite	6.76
Apatite	1.45
Pyrite	0.17
	101.17

C. I. P. W. Classification

II(III).'5.2'.4.

kilauose-akerose

Chemical analysis by C. Trimble

TABLE 5. Chemical Analysis, Norm, and C. I. P. W. Classification of Sample Takahe-D.

Chemical Analysis	Wt. %
SiO_2	60.43
TiO_2	0.59
Al_2O_3	14.90
Fe_2O_3	2.87
FeO	6.17
MnO	0.106
MgO	0.02
CaO	1.78
Na_2O	8.38
K_2O	4.68
P_2O_5	0.14
ZrO_2	0.23
Li_2O	0.052
H_2O+	0.27
H_2O-	0.08
CO_2	ND
S	0.05
Total	100.75

Norm	
Orthoclase . . .	27.80
Albite	44.02
Nephelite . . .	2.84
Diopside	7.94
Olivine	4.69
Ilmenite	1.06
Zircon	0.37
Acmite	8.32
Pyrite	0.14
Na Metasilicates	2.81
	99.99

C. I. P. W. Classification

II.5.4'.'4.

hessose

Chemical analysis by C. Trimble

TABLE 6. Average Chemical Analysis, Norm, and C. I. P. W. Classification of Samples Takahe-A, B, C, D.

Average Chemical Analysis	Wt. %
SiO_2	52.82
TiO_2	2.27
Al_2O_3	15.52
Fe_2O_3	1.41
FeO	8.50
MnO	0.079
MgO	3.30
CaO	6.13
Na_2O	5.70
K_2O	2.79
P_2O_5	0.97
ZrO_2	0.10
Li_2O	0.052
H_2O+	0.19
H_2O-	0.10
CO_2	ND
S	0.075
Total	100.01

Average Norm	
Orthoclase . . .	16.40
Albite	32.75
Anorthite . . .	11.21
Nephelite . . .	5.40
Diopside	15.58
Olivine	8.61
Magnetite . . .	1.05
Ilmenite	4.66
Apatite	1.09
Zircon	0.09
Acmite	2.08
Pyrite	0.16
	99.78

Orthoclase-albite-anorthite ratio (calculated from norm)
$Or_{27}\ Ab_{54}\ An_{19}$

C. I. P. W. Classification

II'.'5.2.4.

akerose

TABLE 7

Analogues of Takahe Lavas

Item	28	C_1	T-D	30	31	32	b	57	T-ABCD
SiO_2	64.13	63.20	60.43	61.01	58.94	58.93	49.24	52.93	52.82
TiO_2	0.65	0.46	0.59	—	1.40	1.25	1.84	2.29	2.27
Al_2O_3	14.32	17.45	14.90	16.62	16.33	18.16	15.84	15.86	15.52
Fe_2O_3	5.58	3.60	2.87	3.55	2.48	0.64	6.09	2.01	1.41
FeO	0.70	—	6.17	2.81	5.54	5.18	7.18	8.90	8.50
MnO	0.12	—	0.11	0.55	0.21	0.07	—	0.11	0.08
MgO	0.72	0.75	0.02	0.06	1.03	2.92	3.02	3.63	3.30
CaO	2.36	1.40	1.78	3.27	2.10	6.14	5.26	7.60	6.13
Na_2O	5.29	6.90	8.38	5.92	5.54	3.42	5.21	5.03	5.70
K_2O	4.86	5.88	4.68	5.22	5.25	2.74	2.10	0.64	2.79
P_2O_5	0.39	—	0.14	tr	0.57	—	0.83	0.35	0.97
ZrO_2	—	—	0.23	—	0.22	—	—	—	0.10
Li_2O	—	—	0.05	—	—	—	—	—	0.05
BaO	—	—	—	—	—	—	—	—	—
H_2O+	0.79	0.50	0.27	1.13	0.42	0.56	1.61	0.42	0.19
H_2O-		—	0.08	—	0.44	0.10	1.08	0.04	0.10
CO_2	—	—	ND	—	0.44	—	—	—	ND
S	—	—	0.05	—	—	—	—	0.06	0.08
Inclusive	—	—	—	—	0.16	0.02	—	—	—
Sum	99.91	100.14	100.75	100.14	100.68	100.11	100.46	99.87	100.01
Quartz		------	------				------		------
Orthoclase		35.00	27.80				12.23		16.40
Albite		48.20	44.02				44.01		32.75
Anorthite		—	—				13.62		11.21
Nephelite		5.40	2.84				—		5.40
Diopside		5.90	7.94				2.97		15.58
Hypersthene		—	—				2.49		—
Olivine		2.40	4.69				6.36		8.61
Magnetite		—	—				9.05		1.05
Ilmenite		0.99	1.06				3.50		4.66
Apatite		—	—				3.36		1.09
Acmite		1.40	8.32				—		2.08
Rest		—	3.32				—		0.95
Sum		97.20	99.99				97.59		99.78

Item	58	C_2	d	6	T-A	T-C	62	4	e	T-B	76	77
SiO_2	50.71	53.04	49.84	51.26	50.16	50.73	47.56	49.55	52.83	49.94	48.88	48.76
TiO_2	2.71	2.12	1.43	2.57	2.63	2.80	2.60	2.09	—	3.05	3.25	3.25
Al_2O_3	17.08	17.34	17.78	16.74	15.87	15.86	18.77	17.78	17.67	15.44	12.46	12.70
Fe_2O_3	1.38	2.12	5.86	2.92	1.55	1.20	1.66	4.65	7.50	nil	3.77	4.23
FeO	8.71	6.96	2.62	7.11	8.75	8.79	7.13	5.89	1.68	10.30	8.09	7.41
MnO	0.09	—	0.21	0.23	0.08	0.04	0.20	0.28	—	0.09	0.15	0.21
MgO	3.63	2.49	3.02	2.80	4.30	4.53	2.82	2.49	2.47	4.35	[illegible]	8.57
CaO	5.75	5.86	7.35	6.61	7.01	7.36	7.82	7.01	7.35	[illegible]	[illegible]	8.70
Na_2O	3.82	5.61	5.20	5.86	5.04	4.88	5.15	6.12	6.61	4.48	3.08	3.04
K_2O	3.63	3.00	3.04	2.25	2.39	2.19	2.68	2.29	2.52	1.90	1.55	1.53
P_2O_5	0.57	0.83	0.76	0.81	1.16	1.22	0.07	1.10	—	1.36	[illegible]	0.43
ZrO_2	—	—	0.03	—	0.05	0.06	—	0.01	—	0.05	—	—
Li_2O	—	—	—	—	0.05	0.05	—	—	—	0.06	—	—
BaO	—	—	0.22	0.10	—	—	—	0.05	—	—	—	—
H_2O+	1.75	0.37	2.02	0.42	0.22	0.14	1.27	0.34	2.32	0.13	0.15	0.33
H_2O-	0.16	—	0.34	0.26	0.11	0.08	0.82	0.29		0.12	0.07	0.66
CO_2	tr	—	0.52	tr	ND	ND	tr	—	—	ND	—	—
S	—	—	—	—	0.09	0.08	—	—	—	0.08	0.01	0.02
Inclusive	—	—	0.18	0.09	—	—	0.27	0.12	—	—	0.20	0.14
Sum	99.99	99.74	100.45	100.03	99.46	100.01	98.82	100.06	100.95	99.73	[illegible]	[illegible]
Quartz		—	—	—	—	—		—	—	—		
Orthoclase		17.79	17.79	12.79	13.90	12.79		13.34	15.00	11.12		
Albite		39.30	32.49	38.25	29.34	30.92		34.58	35.60	26.72		
Anorthite		13.34	16.40	12.79	13.62	14.73		15.01	10.80	16.50		
Nephelite		4.26	6.25	6.25	7.10	5.68		9.09	11.10	5.96		
Diopside		8.57	9.94	12.40	16.76	17.19		10.42	13.40	20.42		
Hypersthene		—	—	—	—	—		—	3.50	—		
Olivine		6.99	2.03	5.69	9.44	9.62		3.80	—	10.70		
Magnetite		3.02	4.87	4.18	2.32	1.86		6.73	5.30	—		
Ilmenite		4.10	2.74	4.86	5.02	6.76		3.95	—	5.78		
Apatite		2.02	1.81	2.02	1.30	1.45		2.69	—	1.59		
Acmite		—	—	—	—	—		—	—	—		
Rest		—	2.40	—	0.17	0.17		—	3.80	0.17		
Sum		99.39	96.72	99.23	98.97	101.17		99.61	98.50	98.96		

28. Phonolitic trachyte (rolled fragment). Possession Islands off Victoria Land (Prior, 1902, p. 329); analyst; G. I. Prior (*** p. 55)

Ic. Nordmarkite (Brögger), phlegrose-nordmarkose, I(II).5'.1.(3)4. Tonsenas, near Christiania, Norway. (**p. 64)

T-D Takahe, sample D (Anderson), hessose, II.5.4.4., Mt. Takahe, Marie Byrd Land, Antarctica; analyst; C. Trimble. (*)

30. Trachyte (water worn pebble?), Cape Adare, Victoria Land (David, Smeeth, and Schofield, 1896, p. 473); analyst: J. A. Schofield ?. (***p. 55)

31. Trachyphonolite, Mt. Cis, Ross Island, Ross Archipelago (Jensen, 1916, p. 122); analyst: J. W. Hogarth. (*** p. 55)

32. Hornblende lamprophyre (Cuff Cape type), eastern end Cuff Cape, Granite Harbor, Victoria Land (Smith, 1924, p. 197); analyst: E. D. Mountain. (***p. 55)

IIIb. Mugearite (Harker), akerose, II.5.2'.4. Island of Skye, Scotland. (**p. 66)

57. Andesine basalt, Deception Island, South Shetland Islands (Barth and Holmsen, 1939, p. 11); analyst: Brynjolf Bruun. (*** p. 56)

T-ABCD. Average of four Takahe analyses (Anderson), akerose, II.''5.2.4., Mt. Takahe, Marie Byrd Land, Antarctica; analyst: C. Trimble (*)

58. Augite-biatite kersantite, G_1, Northern Foothills, Victoria Land (Prior, 1907, p. 130); Analyst: G. T. Prior. (*** p. 56)

IIIc. Olivine trachyandesite (Lacroix), akerose, II.5.2.4. Bellouve, Reunion Island.(**p. 66)

IIId. Trachydolerite (Graton), akerose, II.5'.2'.4. Bull Cliff, Cripple Creek district, Colorado. (** p. 66)

6. Trachyandesite (Cross), akerose, II.5'.3.4. Vieria's ranch, south of Kaupo Gap, Haleakala, Maui. (** p. 51)

T-A. Takahe, sample A (Anderson), Kilauose-akerose, II(III).5(6).2'.4., Mt. Takahe, Marie Byrd Land, Antarctica. (*)

T-C. Takahe, sample C (Anderson), Kilauose-akerose, II(III).'5.2'.4., Mt. Takahe, Marie Byrd Land, Antarctica. (*)

62. Plagioclase kenyte, Turk's Head, Ross Island, Ross Archipelago (Jensen, 1916, p. 122); analyst: J. W. Hogarth. (***p. 56)

4. Trachyandesite (Cross), akerose-essexose, II.5(6).2.4., White Hill, crater of Haleakala, Maui. (**p. 51)

IIb. Carmeloite (Lawson), akerose-essoxose, II.5(6).2.4. Suniom Point, Carmelo Bay, California. (**p. 66)

T-B. Takahe sample B (Anderson), camptonose-andose, (II)III.(4)5.(2)3.4. Mt. Takahe, Marie, Byrd Land, Antarctica. (*)

76. Light-colored basalt, Peter I Island, northeast of Thurston Peninsula (Broch, 1927; p. 38); analyst: Emil Klüver. (*** p. 57)

77. Dark-colored basalt, Peter I Island, northeast of Thurston Peninsula (Broch, 1927; p. 38); analyst: Emil Klüver. (*** p. 57)

Sources of Information

(*) This report

(**) Cross, W., 1915, Lavas of Hawaii and Their Relations: USGS Prof. Paper 88, 97 pp.

(***) Stewart, D., 1956, On the Petrology of Antarctica: Am. Geophysical Union Geophysical Mon. No. 1, Pub. No. 462, pp. 52-74.

TABLE 8. Comparison of Chemical Analyses of Average Plateau Basalts and Olivine Basalts with the Average of the Takahe Analyses.

Constituent	Average of the Takahe Analyses	Average Plateau Basalt Daly, 1944, p. 1391	Average Olivine Basalt Daly, 1944, p. 1365
SiO_2	52.82	50.67	49.58
TiO_2	2.27	2.52	3.17
Al_2O_3	15.52	13.30	13.19
Fe_2O_3	1.41	3.52	2.40
FeO	8.50	10.34	9.49
MnO	0.08	0.19	0.12
MgO	3.30	6.00	8.30
CaO	6.13	10.15	10.69
Na_2O	5.70	2.40	2.25
K_2O	2.79	0.60	0.55
P_2O_5	0.97	0.31	0.26
Total	99.49	100.00	100.00

TABLE 9. Comparison of the Average of the Takahe Analyses with an Average Hawaiian Oligoclase Andesite.

Constituent	Average of the Takahe Analyses	Average Hawaiian Oligoclase-andesite Stearns & MacDonald, 1947, p. 102
SiO_2	52.82	51.35
TiO_2	2.27	2.74
Al_2O_3	15.52	16.34
Fe_2O_3	1.41	4.64
FeO	8.50	6.19
MnO	0.08	0.20
MgO	3.30	3.73
CaO	6.13	6.61
Na_2O	5.70	5.01
K_2O	2.79	1.94
P_2O_5	0.97	1.00
Total	99.49	99.75

The Sentinel Mountains

The Sentinel Mountains were named by Lincoln Ellsworth in 1935, when he discovered them during his historic trans-Antarctic flight from Dundee Island at the northern tip of Palmer Peninsula to Byrd's Little America on the Ross Ice Shelf. He established their position as about 88° W. and between 77-1/4° and 78-1/3° S. (Joerg, 1936, p. 459). The position determined by the Byrd Station Traverse party is from 77°36' to 78°27' S., and from 85°53' to 87°27' W. (Fig. 1).

Six days were spent in the area, and positions of the range and major peaks are considered accurate to one mile. Positions and elevations of 24 distinct mountain peaks of the Sentinel Range were determined. The locations and elevations above sea level of these peaks were given tentative names by the traverse party to facilitate identification (Anderson, 1958, p. 263).

The ice surface elevation immediately west of the Sentinel Range is about 1,600 meters, and the highest peaks of the range are more than 4,600 meters above sea level (Fig. 16).

In the Sentinel Mountains only the Fisher and Larson Nunataks, situated a few miles west of the main range, were investigated.

The rock specimens collected from these nunataks were designated SF (Fisher Nunatak) and SL (Larson Nunatak). Specimens designated S3 and S4 were collected from two small, isolated outcrops on Larson Nunatak. The main structural and petrologic features are summarized in Table 1.

Fisher Nunatak (SF Series)

The Fisher Nunatak is a sharply pointed, relatively snow-free, quartzite ridge which rises about 130 meters above the adjacent ice surface about 10 miles west of the main portion of the Sentinel Range (Fig. 17). The ridge is arête-like and trends east-west. It consists of steeply dipping (about 60° eastward) quartzite and chlorite schist. The chlorite schist constitutes the central portion of the nunatak and is topographically lower and obviously less resistant than the bounding quartzite units which form twin summits. Numerous faults, the contorted chlorite schist, mineralized fractures, and the steeply dipping beds are indicative of intense deformation. In addition, a huge, recumbent isoclinal fold was seen on a sheer vertical face of Mt. Cerberus (77°58.7', 86°09'), one of the high peaks of the Sentinel Mountain Range.

The quartzite of the Fisher Nunatak, which is generally green and massive, consists of 50 per cent and 75 per cent fairly well rounded, equidimensional quartz set in a sericite-chlorite matrix. A few specimens show primary bedding which is indicated by sorting differences or by concentrations of heavy minerals along bedding planes.

The chlorite schist is dark green and has a sericite-chlorite matrix. A few specimens exhibit a deep reddish-brown color because of hematite. The schist is strongly contorted and fractured. Quartz and calcite veins cut the bedding.

Larson Nunatak (SL, S3, S4 Series)

Larson Nunatak is a snow-covered mound which rises about 300 meters above the adjacent ice surface. There are only a few outcrops. Several samples of slightly schistose, green quartzite and a slightly metamorphosed, black quartzitic sandstone were collected from two low outcrops on the flank of Larson Nunatak (S3 and S4 Series). A sericite-chlorite matrix and abundant calcite are present in all specimens.

A relatively large collection was obtained from the summit. This makes up the SL Series: 12 chlorite-schist specimens, 7 quartzite specimens, and 1 sample of a quartz-calcite vein. A greenish, sericite-chlorite matrix is present, although extensive limonite staining, which is characteristic of most specimens, tends to obscure the greenish color. Veins of quartz, calcite, and mixtures of these two minerals are present in many specimens. Samples from Larson Nunatak are generally more calcareous than those from Fisher Nunatak.

MT. JOHNS (J SERIES)

Mt. Johns, named by the traverse party, is located at 79°37.5' S. and 91°14' W., about 100 miles southwest of the Sentinel Mountains (Fig. 1). It is a solitary, sharp snow-covered nunatak which rises 90 meters above the surrounding ice surface (Fig. 18). Nine samples from the only two outcrops apparent on the nunatak, primarily massive, greenish quartzite, were studied; and a complete petrographic description of each is included in Appendix II.

The main structural and petrologic features are summarized in Table 1. The groundmass of the quartzite consists of a fine-grained chloritic, calcareous material and possibly some fine-grained sericite. There is a large assemblage of heavy minerals. Specimens exhibit ripple marks, sorting and graded bedding. The quartzite beds are relatively free of the mineralized fractures and veins which are so abundant in the chlorite schists of the Sentinel Mountains.

MT. EWING (E SERIES)

Mt. Ewing, named by the traverse party, is located at 80°25.2' S. and 97°45' W., about 80 miles west-southwest of Mt. Johns and some 180 miles southwest of the Sentinel Mountains (Fig. 1). It is a snow-covered nunatak which rises about 300 meters above the adjacent ice surface (Fig. 19). One snow-free ridge, extending from the base of Mt. Ewing almost to the summit, was sampled. Of the 13 specimens studied from the Mt. Ewing collection (E Series), five are slightly metamorphosed quartzitic sandstones, three are quartzites, three are chlorite schists, and two are vein material.

With the exception of the green chlorite schist and the white vein samples, limonite staining colors the specimens tan to brown. The matrix consists of sericite, chlorite, and calcite. Heavy minerals are generally absent. Calcite and quartz are the dominant constituents of the many veins, stringers, and mineralized fractures.

CONCLUSION

Lithologic, petrographic, and structural evidence seems to indicate that the Sentinel Mountains, Mt. Johns, and Mt. Ewing can be related. The rocks of these three areas consist of a metasedimentary sequence of the green schist facies. Quartzite and chlorite schist are the dominant rocks.

The three outcrop masses also are petrographically similar. Granular quartz is the dominant mineral in most of the specimens from all three localities. A sericite-chlorite matrix is common to most of the specimens. Limonitic staining is evident in some specimens gathered from each locality.

The general strike of each of the three masses is slightly east of north. The exception is Mt. Ewing, which strikes N. 50° E. However, at high latitudes where meridians rapidly converge, directions of strike vary appreciably over small horizontal distances.

However, the most striking evidence which indicates that all three localities are part of the same structure is based on seismic and gravity data, obtained along the traverse route between these three localities. These data (Ostenso and Bentley, 1959) show the existence of an extremely irregular, rock-ice interface all along the route from the Sentinel Mountains to Mt. Ewing. Mt. Johns and Mt. Ewing are the only points south of the Sentinel Mountains, along the traverse route, where this irregular surface is exposed. Ostenso and Bentley (1959) state that the seismic data indicate an extension of the Sentinel structure to the southwest, at least as far as 80°30' S., 98° W. vicinity of Mt. Ewing.

The data collected by the Byrd Station Traverse party indicate that the Sentinel Mountain structure extends southwestward at least to Mt. Ewing. It is conceivable that the structure may extend southward beyond Mt. Ewing. A 1958-1959 oversnow traverse from Ellsworth Station, on the Weddell Sea, to Byrd Station discovered mountains to the south of Mt. Johns and Mt. Ewing. The samples collected from some of these mountains consist of metamorphic and intrusive rocks. Detailed examination of the Ellsworth collection will be necessary to ascertain whether these mountains actually are a southward extension of the Sentinel structure.

In addition, a series of mountain peaks were sighted to the southeast of Byrd Station by a 1958-1959 Byrd Station Traverse party which was traveling south to the Horlick Mountains. The existence of these newly discovered mountains south of the 80th parallel in Marie Byrd Land appears to discount the supposition that a great "Antarctic Graben" extends from the Ross Sea to the Weddell Sea. More data, however, concerning the ice thickness and mountain masses south of the 80th parallel, between the Ross and Weddell Seas, will have to be gathered before the existence of such a graben can be definitely proved or discounted. It is conceivable that the supposed graben may lie very close to the Horlick Mountains (about 85°S.) or may even narrow in passing through Marie Byrd Land.

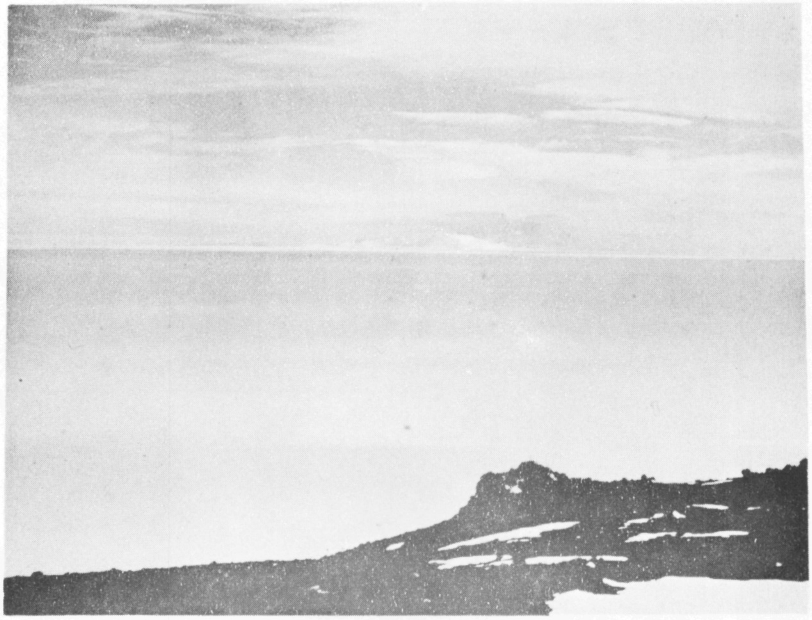


Fig. 14. Toney Mountain as seen from the cinder cone locality on Mt. Takahe.

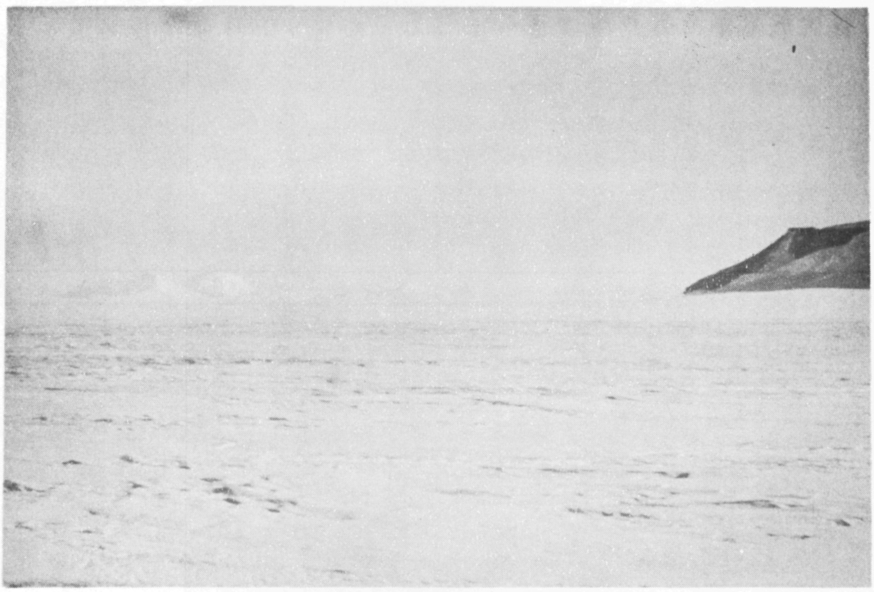


Fig. 15. Peaks of the Kohler Range--Mt. Takahe in right foreground.

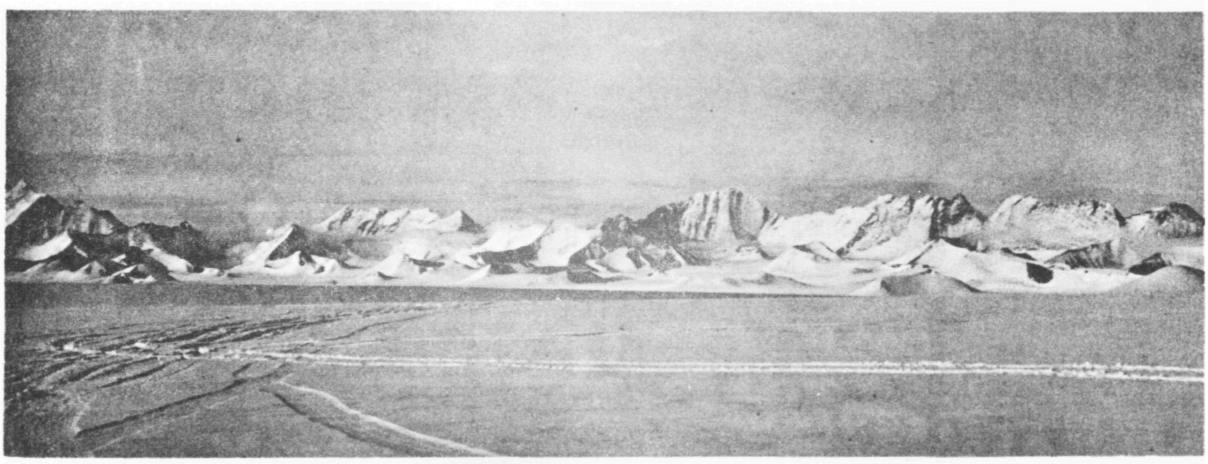


Fig. 16. View of part of the Sentinel Range.

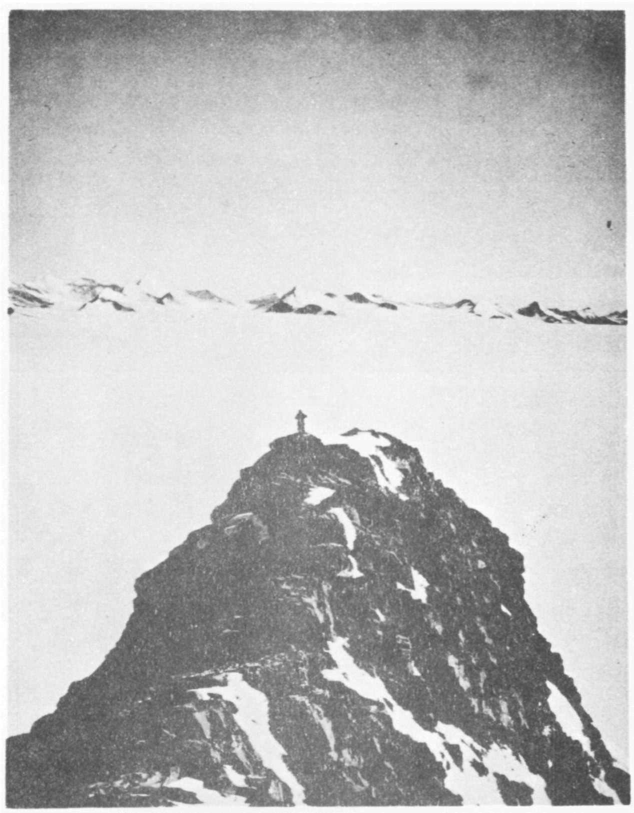


Fig. 17. Summit ridge of Fisher Nunatak, looking eastward toward the Sentinel Range.

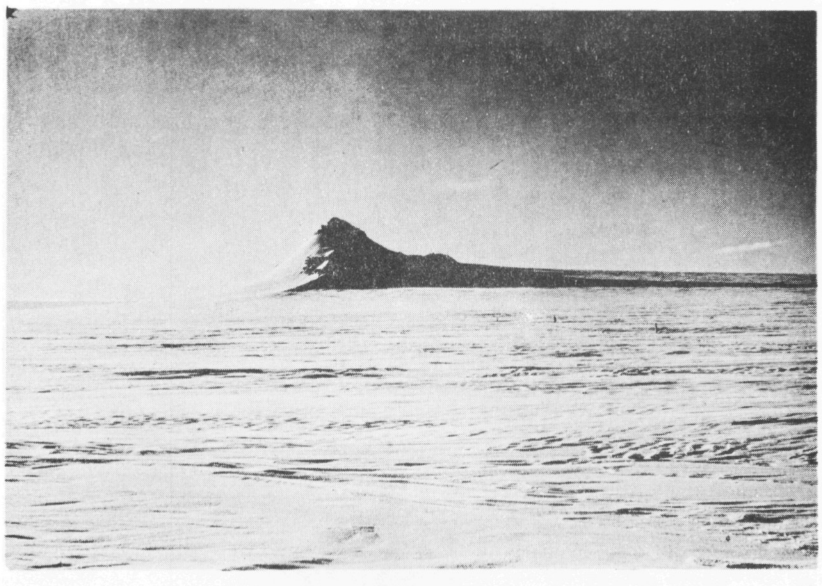


Fig. 18. View of Mt. Johns.

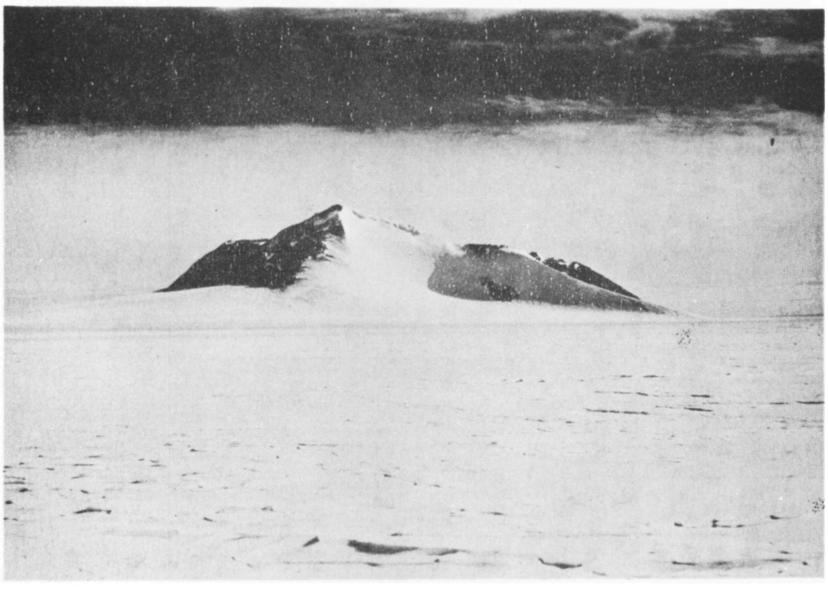


Fig. 19. View of Mt. Ewing.

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APPENDIX I

PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM MT. TAKAHE

PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM MT. TAKAHE

Sample T-A, first of a series of four chemically analyzed specimens, is a very dark, sooty-grey, vesicular andesite. Altered phenocrysts of plagioclase as long as 2 cm occur in the glassy groundmass. The vesicles are mostly spherical and attain sizes of 8 mm in diameter.

The groundmass, constituting about 80% of the specimen, consists of microlites of plagioclase set in an opaque, brownish-black, iron-rich glass. The texture is hyaloophitic. Microlitic plagioclase laths about 0.1 mm long are randomly distributed throughout and constitute about 40% of the groundmass.

Phenocrysts consist of large, as long as 2 cm, plagioclase crystals (andesine-oligoclase), pyroxene (pigeonite), small olivine cyrstals, about 0.2 mm in diameter, and magnetite which is associated with the olivine and disseminated throughout the specimen. A few phenocrysts of zoned sanidine or albite are present.

According to the C.I.P.W. classification this specimen is kilauose-akerose, II(III).5(6).2'.4.

Sample T-B, which was also chemically analyzed, is a dark, sooty-grey, vesicular andesite. The vesicles in this specimen are quite small and are less than 1 mm in diameter. Skeletal plagioclase crystals, about 1 cm long, are present.

The groundmass, comprising about 80% of the specimen, consists of a dark, brownish-black glass (about 60%) and microlitic plagioclase (about 40%). The texture is hyaloophitic. Magnetite is present in the groundmass, small grains being disseminated throughout.

Phenocrysts consist of plagioclase (oligoclase) a pyroxene (pigeonite?), olivine, and magnetite. Only one or two large (over 0.7 mm in diameter) phenocrysts of olivine are present in thin section, most crystals are less than 0.3 mm in diameter. Magnetite, closely associated with the olivine, is present as black inclusions in the smaller olivine crystals.

According to the C.I.P.W. classification, this specimen is camptonose-andose, II(III).(4)5.(2)3.4.

Sample T-C, the third sample to be chemically analyzed~~, is~~ a rather poorly consolidated, fractured, sooty-dark grey, vesicular andesite. The vesicles are very small, usually less than 0.5 mm in diameter. The specimen is aphanitic.

The groundmass comprises over 90% of the specimen; phenocrysts are rare and generally small. The groundmass consists of a dark, brownish black, glassy material and rare microlitic plagioclase crystals. The smaller vesicles appear to be filled with an isotropic substance which was not present in previous samples.

Phenocrysts constitute about 10% of the specimen. Skeletal crystals of plagioclase (oligoclase) are present. A pyroxene with an extinction angle of 45° (augite?) is also present and small magnetite crystals are disseminated throughout.

According to the C.I.P.W. classification, this specimen is kilauose-akerose, II(III).'5.2'.4.

Sample T-D is the fourth and final sample to be chemically analyzed. It is a dense, black, semi-glossy rock, having a conchoidal fracture. Impurities and inclusions are sparsely disseminated throughout, but only a few feldspar crystals can be identified in hand specimen. Vesicles are practically absent.

The groundmass comprises about 95% of the entire specimen. Brownish-black crystallites are the most prominent constituent of the groundmass. Vague orientation or alignment gives the specimen a faint flow structure.

Phenocrysts consist of a few small (less than 1 mm in diameter) sanidine crystals and a few crystals of even smaller pyroxene (pigeonite). Fine-grained, magnetite or ilmenite, are abundant and are scattered throughout the glassy groundmass.

According to the C.I.P.W. classification, this specimen is hessose, II.5.4'.'4.

Sample T-1 is a dark, sooty-grey vesicular andesite similar to sample T-A. Vesicles comprise about 40% of the specimen. The size of the vesicles range from about 0.3 mm to over 8.0 mm, the average being about 3 mm in diameter. Some vesicles are spherical and others are elongated. Large skeletal plagioclase crystals (5 to 6 mm long) are rare constituents.

The groundmass comprises about 80% of the specimen. Randomly oriented plagioclase laths, with a maximum size of about 0.5 mm by 0.07 mm, are disseminated throughout the groundmass. Also present in the groundmass are minute crystals of sanidine, olivine, pyroxene, and minor magnetite. These microlites are set in a dark, brownish black, glass. The texture is hyaloophitic.

The phenocrysts consist primarily of pyroxene, plagioclase, and magnetite, and rare olivine. Oligoclase is fresh and unaltered, and has sharp, angular crystal boundaries. Olivine is altered to magnetite.

Glass near the boundaries of vesicles lacks plagioclase microlites.

Sample T-2 is a slightly denser variety of the previous sample, T-1. Vesicles comprise about 30% of the specimen, are commonly spherical, and have a maximum diameter of about 2 mm; most, however, are about 1 mm diameter. This specimen is also a dark, sooty-grey, vesicular andesite. A few skeletal crystals of plagioclase are identifiable in hand specimen.

The groundmass comprises about 80% of the specimen. Plagioclase microlites are the most abundant mineral of the groundmass. These microlites are set in a dark, brownish glass. The microlitic plagioclase laths are about 0.3 to 0.4 mm in length. Tiny crystals of sanidine, pyroxene, olivine, and magnetite also occur in the groundmass.

The phenocrysts consist primarily of large crystals of plagioclase (andesine-oligoclase) and pyroxene (diopside-augite). The plagioclase phenocrysts are about 4 mm long and about 1 mm wide. Crystal boundaries are sharp and well defined. The pyroxene phenocrysts are smaller and not as well formed. Smaller crystals of olivine and magnetite are quite abundant.

The borders of the vesicles are dark brownish glass, and lack the plagioclase microlites.

Sample T-3 is a dark, sooty grey, vesicular basalt. Vesicles comprise about 25 to 30% of the specimen. They range from less than 0.1 mm to about 4.0 mm in diameter and are dominantly spherical. This specimen is aphanitic.

The groundmass consists of dark, brownish-black glass. Microlitic plagioclase crystals are either less abundant than in most previously examined specimens, or are masked by the opaque brown glass.

The phenocrysts consist of plagioclase (labradorite), pyroxene (diopside-augite), abundant olivine, and a profusion of finely disseminated magnetite crystals. Magnetite is commonly present in the interior of small olivine crystals. Randomly oriented plagioclase laths with average length of about 0.3 mm are abundant.

Plagioclase phenocrysts form a portion of some vesicle walls. Commonly, however, the brownish-black glass forms the margins of vesicles.

Sample T-4 is a sooty grey vesicular andesite. It is lighter in color than the previous specimens and its vesicles are smaller. The largest vesicles are about 1.0 mm in diameter, the more numerous smaller vesicles average about 0.3 mm in diameter. The vesicles are not mineralized. Skeletal crystals of plagioclase about 1 cm long are obvious in hand specimens.

The groundmass, comprising 80 to 90% of the specimen, consists of microlitic plagioclase set in brownish-black glass. The plagioclase microlites average about 0.2 mm in length.

A few phenocrysts of plagioclase (oligoclase) and only a few small pyroxene crystals are present. Magnetite is disseminated throughout as very small crystals. A few larger crystals of magnetite (about 0.2 mm in size) are also present. Tiny crystals of olivine are also present and are closely associated with magnetite. Nearly every olivine crystal contains specks of magnetite.

Sample T-5 is another specimen of a dark, sooty-grey, vesicular basalt. The vesicles are generally elongate and irregular in contrast to the predominantly spherical vesicles of other specimens.

The groundmass comprises about 60% of the specimen, the major constituents being magnetite and brownish-black glass. Microlites of plagioclase are scarce.

Phenocrysts consist of plagioclase (labradorite), olivine, magnetite, and pyroxene, the latter being least abundant. Plagioclase laths as long as 1.0 mm are the most abundant phenocrysts; olivine and magnetite, closely associated, are slightly less abundant. The labradorite phenocrysts appear to represent a growth of former microlitic laths. The pyroxene is diopsitic augite.

Sample T-6 is a poorly consolidated, brownish-grey, coarsely crystalline, vesicular andesite. Many irregular voids occur between crystallized minerals. Although the crystals are quite large (many over 1 cm in size), only magnetite is identifiable megascopically. The entire specimen has the general appearance of a rough, irregular, sooty-grey cinder.

The groundmass, consisting of brownish glass, comprises only about 25% of the specimen.

The phenocrysts consist of plagioclase (andesine), pyroxene (diopsitic-augite), olivine, and magnetite and occur as extremely large crystals (up to 1 cm). Magnetite, occurring as anhedral and euhedral crystals, is associated with pyroxene and olivine phenocrysts. The olivine is forsterite, recognized by its large 2V.

Sample T-7 is a blocky, rather dense, dark sooty-grey, vesicular andesite. The specimen is extensively altered, fractured and breaks readily. It exhibits phenocrysts of plagioclase and is a porphyritic aphanitic. Vesicles are not abundant and are less than 0.5 mm in diameter.

The groundmass, constituting about 80% of the specimen is primarily opaque, brownish glass. Microlitic plagioclase laths occur in the glass, but not nearly in the amount evident in most of the previously described specimens. Small magnetite crystals are disseminated throughout the groundmass.

Phenocrysts consist of skeletal and euhedral plagioclase crystals (oligoclase) and pyroxene (diopsitic-augite?). A few phenocrysts of magnetite are present; olivine phenocrysts are absent.

Sample T-8 is a spotty, brown and black, poorly consolidated volcanic agglomerate. Fragments of a black, vesicular basalt are set in a brownish groundmass of glass. The weathered surface is very rough, porous, and cinder-like. Both the matrix and basalt fragments are aphanitic.

The groundmass, consisting of microlitic plagioclase partially obscured by the more abundant brownish glass, comprises about 75% of the specimen.

Phenocrysts include plagioclase (labradorite) laths, olivine, and magnetite. Magnetite is present in most of the small olivine phenocrysts. Magnetite is also present in euhedral crystals, in elongate splinters, and more commonly as irregular and rounded crystals.

Sample T-9 is a mottled, purplish green, platy rock. It is aphanitic except for a few large plagioclase phenocrysts and exhibits slaty cleavage breaking into thin sheets or slabs. It was collected as float from the cinder cone locality.

The groundmass, comprising almost 100% of the specimen, is a mixture of fine-grained plagioclase and chlorite. A reddish-brown mineral, probably hematite, is disseminated throughout.

Phenocrysts of plagioclase (albite) and pyroxene (augite) are present. The plagioclase crystals are about 1 cm long; the pyroxene phenocrysts are much smaller (less than 1 mm). The plagioclase phenocrysts are very fresh and have sharp, distinct crystal boundaries; the border of the pyroxene crystals appear to be resorbed into the groundmass.

Sample T-10 is a dense, fine-grained, greenish-grey metasedimentary rock. It occurs as float on the cinder cone on Mt. Takahe.

The groundmass consists of a mixture of a feldspar with a brownish, fine-grained material. Fine-grained chlorite is disseminated throughout the groundmass and gives a greenish hue to the specimen.

Phenocrysts of chlorite, usually less than 0.3 mm in diameter, are intermingled with hematite. Pleochroic, greenish-brown epidote may be present. Plagioclase crystals (albite), partially obscured by the groundmass, are also present. Free quartz may be present although it was not positively identified.

Sample T-11 is a very dense, semi-glossy, black rock very similar to sample T-D. This specimen lacks vesicles or cavities, has a conchoidal fracture, and exhibits a few inclusions of feldspar.

The groundmass is a streaky, brownish glass and constitutes more than 95% of the specimen. Crystallites are the primary constituent of this groundmass.

Phenocrysts consist of a few small feldspar crystals, probably sanidine and some phenocrysts of magnetite.

Sample T-12 is a dense, speckled, dark blue and light bluish-grey, igneous rock (syenite). The specimen, probably brought up from depth by volcanic action, was found as float on the cinder cone. The texture is fine grained. Light bluish-grey plagioclase contain euhedral magnetite.

The groundmass, comprising about 60% of the specimen, consists of intergrown, broad, plagioclase laths (albite) which exhibits polysynthetic Carlsbad and albite twins.

Phenocrysts consist of radiating, fibrous prochlorite, aegerine-augite, a pyroxene (diopside), an amphibole (hornblende), and some hematite. The aegerine-augite is zoned. Large euhedral hematite crystals are most abundant and are often associated with the pyroxene. Some large euhedral crystals of sodalite or analcite are present. Most of the phenocrysts are euhedral, some are fractured.

Sample T-13 is a coarsely crystalline, rather loosely consolidated, example of sample T-12. This specimen could be called an aegerine-augite syenite. The matrix consists of very large plagioclase laths which may reach a length of 1 cm. Large euhedral crystals of hematite fill the voids between the plagioclase laths.

The entire specimen consists of large crystals of perthite, hematite, and aegerine-augite. Aegerine forms the outer rims of the aegerine-augite crystals. Perthite is much more abundant than albite. The hematite stains some of the surrounding plagioclase yellow.

Sample T-14 is a welded tuff collected from the volcanic neck locality of Mt. Takahe. It is an agglomerate and has a greyish-green matrix with brownish black inclusions. The specimen is finely vesicular and aphanitic.

The greyish green groundmass constitutes about 65% of the specimen. It is composed of dark, greenish-brown glass. Glass crystallites are aligned parallel to flow lines.

Phenocrysts consist of a few small, widely scattered feldspar crystals (sanidine?) and an abundance of small hematite grains.

Sample T-15 is a welded tuff collected from the volcanic neck locality of Mt. Takahe. It is scoriaceous and exhibits strongly contorted flow lines. The matrix is a light brownish glass which encloses "smeared" fragments of a dark grey material.

The groundmass consists of a dark, brownish-black glass. Flow structure is shown by oriented crystallites. The specimen is quite vesicular, vesicles being generally elongate.

Phenocrysts are rare and small. A few crystals of twinned plagioclase (albite) are present. Phenocrysts comprise less than 5% of the specimen.

Sample T-16 is a welded tuff collected from the volcanic neck locality of Mt. Takahe. It is a brownish rock and consists of a myriad of rock fragments of various sizes and shapes. Particles of volcanic, igneous, and even sedimentary rocks are part of the agglomerate.

The groundmass consists of brownish, opaque glass. Vesicles are abundant and randomly scattered throughout the entire groundmass.

Phenocrysts consist of a few plagioclase crystals (albite?) and a few small pyroxene crystals (augite?). Andesites, basalts, and syenites are present as fragments.

Sample T-17 (an unlabeled and unsectioned specimen) is a purplish-brown volcanic agglomerate. It consists of a brownish, glassy groundmass and anhedral oligoclase (An_{25}) phenocrysts. Some of these oligoclase crystals are over 2.5 cm long and almost 1 cm wide.

The rock is very coarse and was collected from the Takahe volcanic neck. The matrix is very vesicular, almost pumaceous.

APPENDIX II

PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM THE SENTINEL RANGE

PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM THE SENTINEL RANGE
FISHER NUNATAK COLLECTION

Sample SF-1 is a massive, greenish-grey, sugary-textured quartzite. Detrital quartz, plagioclase, garnet, muscovite, and hematite comprise about 80% of the specimen. Quartz alone comprises about 60%. The grains range from less than 0.1 mm to about 0.4 mm in diameter and are mostly xenoblastic. A fine-grained mixture of sericite and chlorite, comprising about 20% of the specimen, is present in the interstices. A few isolated, well-rounded rutile crystals are also present.

Sample SF-2 is a greenish-grey quartzite cut by a quartz vein. Detrital quartz, plagioclase, microcline, garnet, calcite, and muscovite are present. The grains range from less than 0.1 mm to about 0.2 mm in diameter and are predominantly xenoblastic. Quartz is the most abundant mineral present. The cementing material is a fine-grained mixture of sericite and chlorite. A very small amount of limonite is present.

The quartz vein consists of xenoblastic quartz and calcite crystals as large as 8.0 mm.

Sample SF-3 is a layered, white, green, and brownish-red schistose rock. The white layers consist of quartz; the greenish layers consist of chlorite minerals; and the brownish-red layers are primarily composed of a fine-grained hematite, sericite, and chlorite.

Sample SF-4 is a greenish, schistose specimen having a platy cleavage. Detrital quartz, plagioclase, garnet, and limonite are present. Quartz grains comprise about 50% of the specimen. A fine-grained cement of sericite and chlorite comprises another 50%. A few grains of sphene are disseminated throughout. There is a marked lineation of the cementing material.

Sample SF-5 is a greenish quartzite containing fragments of a deep brownish-red schist. Well-rounded quartz and plagioclase grains comprise about 50% of the specimen. A sericite and chlorite cement comprises the remaining 50%. A few grains of garnet, muscovite, and hematite are also present. Foliation is present both in hand specimen and in thin section.

Sample SF-6 is a greenish-white, fine-grained, quartzitic schist. Subangular, detrital grains of quartz, feldspar, garnet, and limonite comprise about 50% of the specimen. Grain size does not exceed 0.3 mm. A fine-grained sericite, chlorite matrix comprises the rest of the specimen. A few grains of epidote are present.

Sample SF-7 is a green and white chlorite schist. Detrital quartz, plagioclase, microcline, muscovite, epidote, and hematite are present. Quartz is the most abundant mineral present. A fine-grained matrix of sericite and chlorite constitute the remaining portion. The rock is well foliated.

Some small veins of quartz and calcite cut the schist.

Sample SF-8 is a dark, greenish-brown, chlorite schist. Detrital quartz, plagioclase, garnet, chlorite (clinochlore), epidote, muscovite, limonite, and hematite are present. Maximum grain size is about 0.5 mm in diameter and all the grains are rounded to subrounded. The modal analysis is as follows:

Quartz	55.0%
Garnet	6.0
Chlorite	4.0
Limonite	2.0
Micas	1.0
Epidote	0.7
Hematite	0.7
Feldspar	0.1

A matrix of sericite and chlorite constitutes the remaining 30%.

Weathered surfaces are iron stained.

Sample SF-9 is a mottled, green and white portion of a quartz vein. Quartz crystals, comprising about 75% of the specimen, are predominantly long and narrow (less than 0.1 mm by 5.0 mm) and are strained. The greenish portions of the specimen consist of small fragments--quartz, feldspar, epidote, and muscovite in a very fine-grained, chloritic matrix. Some limonite is present.

Sample SF-10 is a massive, greenish-white quartzite and consists of detrital quartz, plagioclase, microcline, garnet, epidote, muscovite, and hematite. The maximum grain size is 0.8 mm in diameter. Quartz grains comrpise about 75% of the rock. The matrix consists of a mixture of fine-grained sericite and chlorite.

Sample SF-11 is a massive, greenish-white quartzite and consists of detrital quartz, plagioclase, microcline, calcite, muscovite, garnet, rutile, and hematite. Quartz comprises about 60% of the specimen. The detrital minerals are set in a sericite-chlorite cement.

Sample SF-12 is a greenish-white quartzite cut by many small quartz veins. Detrital quartz, plagioclase, microcline, calcite, muscovite, garnet, and hematite are present. The matrix consists of a mixture of sericite and chlorite. Some fragments of tourmaline are present, and the rock is slightly stained by limonite.

Quartz and small calcite crystals fill the vein.

Sample SL-1 is a greenish-brown, micaceous, chlorite schist and consists of detrital quartz and muscovite. The grain size ranges from 0.1 mm to 0.2 mm in diameter. The matrix is composed of sericite and chlorite. A brownish limonitic stain obscures the grains and matrix.

Sample SL-2 is a greenish-brown, micaceous, chlorite schist. Detrital quartz, muscovite and chlorite are set in a matrix of sericite and chlorite. Limonite stain obscures the matrix and grains.

Sample SL-3 is a mottled, brown and green, chlorite schist. Detrital quartz, plagioclase, microcline, and tremolite-actinolite are present. The matrix consists of sericite and chlorite. Limonite stain is present throughout.

Thin, quartz-filled fractures cut the limonite and foliation.

Sample SL-4 is a brown, streaked, dark green schist. Detrital quartz, chlorite, plagioclase, muscovite, and hematite are present. A sericite-chlorite matrix is present. Limonitic staining is ubiquitous.

Sample SL-5 is a massive, greenish-grey quartzite and consists of detrital quartz, plagioclase, microcline, calcite, muscovite, and hematite. Most of the grains are xenoblastic and are about 0.5 mm in diameter. Quartz comprises about 65% of the rock and granular calcite comprises about 15%. Sericite and chlorite comprise the fine-grained matrix.

Sample SL-6 is a massive, fine-grained, greenish-grey quartzite. Detrital quartz, calcite, plagioclase, microcline, muscovite, chlorite, and hematite are present. Granular calcite comprises about 30% of the specimen, quartz comprises about 50%, and a sericite-chlorite matrix comprises about 15%. Some hematitic staining is present.

Sample SL-7 is a massive, greenish-grey quartzite. Detrital quartz, calcite, plagioclase, microcline, chlorite, muscovite, magnetite, and limonite are present. The calcite constitutes about 50% of the rock. A sericite-chlorite matrix is present. Variable concentration of chlorite and limonite stains impart a streaky appearance to the specimen.

Sample SL-8 is a greenish-grey, chlorite schist containing veins of calcite and quartz. Detrital quartz, muscovite, magnetite, and limonite are present. Chlorite (clinochlore) comprises the matrix. Highly altered muscovite constitutes about 25% of the specimen.

Calcite crystals as long as 7 mm occupy the center of veins, smaller quartz crystals constitute borders.

Sample SL-9 is a tannish-grey quartzite. Detrital quartz, calcite, plagioclase, microcline, muscovite, magnetite, and limonite are present.

The grains range from 0.1 mm to 0.3 mm in diameter. Quartz grains are the most abundant, forming about 65% of the specimen. A few elongate chlorite crystals are present.

Sample SL-10 is a greenish-grey, slightly foliated chlorite schist. Some quartz-calcite veins are attached to surfaces of the specimen. Detrital quartz, calcite, plagioclase, muscovite and hematite are present. A sericite-chlorite matrix gives the specimen a greenish color. Some grains of specular hematite are disseminated throughout.

Calcite crystals as large as 3 mm in diameter occupy the center of veins. Towards the edge of the veins, calcite and quartz are intergrown and, at the borders, small quartz crystals are predominant.

Sample SL-11 is a well foliated, highly calcareous, greyish-green and purple schist. Detrital quartz, calcite, and hematite are present in the specimen. This specimen consists of more than 60% calcite grains as large as 1 mm in diameter. Sericite and chlorite form the fine-grained matrix. The distinct purple bands in the specimen are composed of minute grains of hematite.

Sample SL-12 is a brownish-tan, slightly foliated, fine-grained schist. Detrital quartz, muscovite and limonite are present. Very fine-grained chlorite, sericite and limonite form the matrix. Limonite staining is prominent.

Sample SL-13 is vein material and consists of quartz, calcite, chlorite, and plagioclase. Most of the crystals are idioblastic. The crystals are large, some calcite crystals being 6 mm in diameter. Prochlorite crystals occur along fractures between quartz crystals and give a greenish cast to the specimen.

Sample SL-14 is a greenish-tan, massive, calcareous quartzite. Small xenoblastic crystals of quartz and calcite constitute about 90% of the specimen. Plagioclase, microcline, and hematite are also present.

Sample SL-15 is a dark green, coarse? textured, chlorite schist. A small calcite vein cuts the specimen. Detrital quartz, muscovite, and hematite are present. The matrix consists of feathery chlorite which constitutes about 70% of the specimen.

Sample SL-16 is a strongly contorted, dark green, chlorite schist. Detrital quartz and plagioclase are present. The matrix consists of sericite and chlorite. Small quartz-filled diklets cut across foliation. A calcite vein cuts the specimen.

Sample SL-17 is a brown-streaked, dark green schist. Detrital quartz, feldspar, and muscovite are present in the specimen. The specimen is very fine grained, the maximum grain size being about 0.2 mm in diameter. Sericite and chlorite comprise the fine-grained matrix. Limonite stain is present along foliation planes and in the interstices between minerals.

Sample SL-18 is a brownish-grey, massive, calcareous quartzite. Detrital quartz, calcite, plagioclase, microcline, magnetite, and limonite are present. A chlorite calcite matrix may comprise as much as 25% of the specimen.

Sample SL-19 is a greenish-brown, calcareous quartzite. Detrital fragments consist of quartz, calcite, plagioclase, microcline, muscovite, and hematite. The specimen is fine grained, the largest grains being 0.8 mm in diameter. The matrix consists of chlorite. A few detrital garnets are present.

Sample SL-20 is a dark green, calcareous, well-foliated, chlorite schist. A few porphyroblasts of calcite are present. Fine-grained chlorite is the most abundant constituent. Limonite is disseminated throughout.

Sample S 3-1 is a dark greenish-grey, slightly metamorphosed, black garnetiferous sandstone. Detrital quartz, plagioclase, microcline, garnet, sphene, rutile, and epidote are present. The maximum grain size is about 0.5 mm in diameter. Quartz grains constitute less than 10% of the specimen. Interstitial prehnite and chlorite are present. Metamorphism is shown by strained quartz. Much of the garnet is altered to chlorite.

The specimen exhibits alternating layers in which chlorite-garnet and quartz-feldspar are abundant. These layers probably represent original bedding.

Sample S 3-2 is a slightly greenish-white portion of a quartz vein. The specimen is largely quartz. Quartz crystals 2 mm in diameter are quite common. Irregular greenish areas consist of fine-grained sericite and chlorite.

Sample S 4-1 is a greyish-green, chloritic quartzite. Detrital quartz, plagioclase, microcline, muscovite, garnet, and hematite are present. Rounded quartz grains range from about 0.2 mm to 1.0 mm in diameter and comprise about 50% of the specimen. The detrital grains are set in a sericite-chlorite-calcite matrix which comprises about 40% of the specimen. Garnets are often partially altered to chlorite.

Sample S 4-2 is a greyish-green, chloritic quartzite. Detrital quartz, garnet, plagioclase, microcline, epidote, and muscovite are present. Subrounded quartz grains constitute about 60% of the specimen. A greenish sericite-chlorite matrix comprises about 30% of the specimen. The garnet and muscovite are extensively altered to chlorite.

Sample S 4-3 is a greyish-green, slightly metamorphosed sandstone. Detrital quartz, feldspar, garnet, sphene, and zircon are present. Quartz comprises about 60% of the specimen. The average grain size is about 0.4 mm in diameter, most of the grains being subrounded to rounded. A matrix of sericite and chlorite comprises about 30% of the specimen. The garnet is extensively altered chlorite.

PETROGRAPHIC DESCRIPTIONS OF SAMPLES OF THE MT. JOHNS SUITE

Sample J-1 is a fine-grained, greenish-grey quartzite. Detrital quartz, chlorite, apatite, plagioclase, microcline, garnet, zircon, sphene, tourmaline, corundum(?) and hematite constitute about 80% of the specimen. The grain size ranges from less than 0.1 mm to about 0.5 mm in diameter. About 70% of the detrital minerals are quartz. A very fine-grained, chlorite-calcite matrix constitutes the remaining 20% of the specimen.

This specimen exhibits graded bedding, and an uneven distribution of the heavy minerals reflects the original stratification in the specimen.

Sample J-2 is a fine-grained, purplish-brown, slightly metamorphosed, garnetiferous sandstone. Detrital quartz, microcline, perthite, garnet, chlorite, hematite, zircon, tourmaline, sphene, and corundum(?) are present. The grain size ranges from 0.1 mm to about 0.4 mm in diameter. About 60% of the specimen consists of detrital quartz. A sericite-chlorite matrix constitutes about 20% of the specimen.

The heavy minerals are disseminated.

Sample J-3 is a purplish-brown, fine-grained, garnetiferous quartzite. Detrital quartz, chlorite, plagioclase, microcline, hematite, garnet, zircon, sphene, tourmaline, and corundum(?) are present. Grain size ranges from less than 0.1 mm to about 0.6 mm in diameter; a few quartz grains are 1.0 mm in diameter. Quartz constitutes about 75% of the specimen, garnets about 10%, a fine-grained sericite-chlorite matrix about 10%.

Sharp boundaries between layers of different grain size probably reflect the original stratification. Heavy minerals are much more abundant in the fine-grained layers.

Sample J-4 is a purple and green, streaked, garnetiferous quartzite. Detrital quartz, calcite, chlorite, epidote, plagioclase, hematite, garnet, sphene, zircon, tourmaline and corundum(?) are present. The grain size ranges from about 0.1 mm to 0.5 mm in diameter. Quartz grains comprise about 65% of the specimen, a sericite-chlorite matrix about 25%.

The specimen exhibits graded bedding. Grain size changes and concentrations of heavy mineral grains reflect original stratification.

Sample J-5 is a dark purple, garnetiferous quartzite. Detrital quartz, chlorite, epidote, plagioclase, hornblende(?), hematite, garnet, sphene, zircon, and tourmaline constitute about 75% of the specimen. Quartz constitutes about 65% of the detrital minerals. A sericite-chlorite matrix comprises about 25% of the specimen.

Sample J-6 is a slightly foliated, greenish-grey, calcareous quartzite. Detrital quartz, epidote, garnet, tourmaline, calcite, and hematite comprise about 75% of the specimen. The grain size ranges from 0.1 mm to 0.3 mm in diameter. Quartz comprises about 70% of the specimen and a chloritic-calcareous matrix about 25%.

Sample J-7 is a calcareous quartzite. Detrital quartz, plagioclase, microcline, garnet, muscovite, hematite, chlorite and calcite comprise about 75% of the specimen. The grain size ranges from 0.1 mm to about 0.3 mm in diameter. Quartz grains comprise about 70% of the specimen and a sericite-calcite matrix about 25%.

Sample J-8 is a purple-streaked, greenish-grey quartzite. Detrital quartz, plagioclase, microcline, hornblende, hematite, garnet, zircon, sphene, and tourmaline comprise about 75% of the specimen. The grain size ranges from less than 0.1 mm to 0.5 mm in diameter. Quartz grains comprise more than 60% of the specimen and a sericite-chlorite matrix about 25%.

Abrupt and transitional changes in grain size and the concentration of heavy minerals are probably related to primary stratification. The specimen is ripple marked.

Sample J-9 is a lavender, massive quartzite. Detrital quartz, plagioclase, garnet, zircon, sphene, epidote, and hematite comprise about 80% of the specimen. Grain size ranges from less than 0.1 mm to about 0.4 mm in diameter. Quartz comprises over 70% of the specimen and a sericite-chlorite matrix about 20%.

The specimen exhibits irregular layers of coarse and fine grains. Heavy minerals are most abundant in the finer layers.

PETROGRAPHIC DESCRIPTIONS OF SAMPLES OF THE MT. EWING SUITE

Sample E-1 is a light greenish-tan, chlorite schist. Detrital quartz, plagioclase, muscovite, magnetite, and limonite are present. The matrix consists of very fine-grained sericite and chlorite. Limonite gives the thin sections a spotty, brownish appearance. Schistosity is related to aligned elongate plagioclase and muscovite grains.

Sample E-2 is a brownish-green, slightly metamorphosed sandstone. Detrital quartz, plagioclase, muscovite, and limonite are present. The grain size ranges from less than 0.1 mm to about 0.3 mm in diameter. Quartz and plagioclase grains comprise about 65% of the specimen, interstitial chlorite about 35%.

Quartz crystals in a small vein are as long as 2.00 mm. The vein also contains penninite (chlorite).

Sample E-3 is a highly fractured, yellowish-brown, slightly metamorphosed sandstone. Detrital quartz, plagioclase, and magnetite are present. Quartz and plagioclase comprise about 50% of the specimen; quartz, chlorite, and sericite(?) constitute the cement.

Numerous small quartz veins cut the schistosity. Limonite staining is characteristic.

Sample E-4 is a dark green, fine-grained, sandstone. Detrital quartz and plagioclase are primary constituents and comprise about 65% of the specimen. A chlorite cement constitutes about 30% of the specimen.

Numerous thin, quartz veins are present. Some quartz crystals are 2.0 mm long. Limonitic staining is prominent.

Sample E-5 is a brown-speckled, fine-grained, greenish chlorite schist. Detrital quartz, plagioclase and muscovite are present. The matrix consists of fine-grained sericite and chlorite. Small grains of limonite are disseminated throughout.

Sample E-6 is a greyish-green sandstone. Detrital quartz, plagioclase, muscovite, calcite, and limonite are present. The grain size ranges from less than 0.1 mm to about 1.0 mm in diameter. Fine-grained sericite and chlorite constitute the cement.

Sample E-7 is a light tan, poorly sorted, calcareous quartzite. Detrital quartz, calcite, plagioclase, chlorite, and magnetite are present. Grain size ranges from less than 0.1 mm to about 0.6 mm in diameter. Quartz comprises about 65% of the specimen, calcite about 30%. The cement consists primarily of calcite.

Limonite is disseminated throughout. A few quartz and calcite filled fracture are present.

Sample E-8 is a portion of a coarse-grained quartz vein. Irregular quartz crystals ranging from about 0.1 mm to 20.0 mm in length constitute about 85% of the specimen, limonite about 15%. Small veins of calcite occur in the hand specimen.

Sample E-9 is a white, coarsely crystalline portion of a quartz and calcite vein. The specimen consists of 65% quartz and 35% calcite. Crystals range from 0.1 mm to over 20.0 mm in length. A very small amount of limonite and sericite is present.

Sample E-10 is a dark, bluish-green, massive quartzite. Detrital quartz, plagioclase, and muscovite are present. Grain size ranges from less than 0.1 mm to about 0.3 mm in diameter. Quartz grains comprise about 70% of the specimen, a sericite-chlorite matrix cement about 30%.

Sample E-11 is a mottled, greenish-brown and white, fine-grained chlorite schist. Detrital quartz, plagioclase and muscovite constitute about 50% of the specimen, a matrix of sericite and chlorite 50%. A small amount of limonite is disseminated throughout. Irregular stringers of quartz (about 0.2 mm wide) are present.

Sample E-12 is a very fine-grained, tan, quartzitic siltstone. Limonite and quartz constitute about 50% of the specimen; chlorite, calcite, plagioclase, and muscovite 50%. All grains are less than 0.1 mm in diameter.

Cross-bedding and truncation of bedding both in thin section and in hand specimen are well shown.

Sample E-13 is a fine-grained, dark green, chlorite schist. Detrital quartz, plagioclase, calcite, muscovite, and limonite are present. All grains are less than 0.1 mm in diameter. The matrix consists of sericite and chlorite. Thin quartz and calcite filled fractures are present.